WHAT IS CLAIMED IS:

1. A flash MOCVD system, comprising:

a reaction chamber;

a substrate assembly positioned within the reaction chamber;

a flash evaporator for vaporizing a reactant material to form a reactant gas;

a gas distribution system for uniformly distributing the reactant gas to the substrate assembly.

2. A flash MOCVD system according to Claim 1, wherein the flash evaporator vaporizes the reactant material by heating the reactant material.

3. A flash MOCVD system according to Claim 1, wherein the flash evaporator ultrasonically vaporizes the reactant material.

4. A flash MOCVD system according to Claim 1, wherein

the reactant material is comprised of a solution of at least one precursor and a solvent, and

the flash evaporator vaporizes the solution to form the reactant gas.

5. A flash MOCVD system according to Claim 1, wherein the flash evaporator comprises:

a vessel for containing a liquid precursor solution;

an evaporation chamber;

a heating device arranged in the evaporation chamber; and

a pump for providing a controlled flow of the liquid precursor solution to the heating device in the evaporation chamber.

6. A flash MOCVD system according to Claim 5, wherein the flash evaporator is continuously isolated from atmospheric conditions to prevent water vapor from condensing on internal surfaces thereof.

7. A flash MOCVD system according to Claim 5, wherein the evaporation chamber is maintained at an elevated temperature to prevent water vapor from condensing on internal surfaces thereof.

8. A flash MOCVD system according to Claim 1,

wherein the flash evaporator is an ultrasonic flash evaporator comprising:

a nozzle formed of a nozzle body and a nozzle stem;

a cooling device arranged to maintain a temperature of the nozzle body below a Curie temperature of piezoelectric material in the nozzle;

a heating device arranged to maintain a temperature of the nozzle stem above a temperature at which liquid condenses on the nozzle stem and but below the Curie temperature of the piezoelectric material in the nozzle, and

wherein the reactant material passes through the nozzle and is vaporized by ultrasonic waves launched through the nozzle, such that as the reactant material exits the nozzle stem the ultrasonic waves vaporize the reactant material to form the reactant gas.

9. A flash MOCVD system according to Claim 1,

wherein the gas distribution system comprises:

a zone-distribution section arranged to respectively confine a plurality of quantities of the reactant gas to a plurality of zones;

a first flow homogenizer positioned downstream of the zone-distribution section, wherein the first flow homogenizer is formed with a plurality of through-holes therein;

a cooling section positioned downstream of the first flow homogenizer, wherein the cooling section is comprised of one or more pipes through which a coolant flows;

a second flow homogenizer positioned downstream of the cooling section, wherein the second flow homogenizer is formed with a plurality of through holes therein,

wherein the cooling section is in physical contact with the first and second flow homogenizers,

wherein a density of through-holes in the first flow homogenizer is greater than a density of through-holes in the second flow homogenizer, and

wherein the quantities of the reactant gas respectively confined in the plurality of zones varies with a respective volume of the plurality of zones.

10. A flash MOCVD system according to Claim 9,

wherein the zone-distribution section is formed with walls,

wherein each of the walls contacts an interior surface of the reaction chamber via a sealing device, which prevents the reactant gas from freely flowing between the plurality of zones through one or more openings between the zone-distribution section and the walls.

11. A flash MOCVD system according to Claim 9, wherein the plurality of zones is concentric.

12. A flash MOCVD system according to Claim 10,

wherein the walls of the zone-distribution section include a wall bisecting the zone-distribution section into a first half and a second half, such that each zone of the plurality of zones is bisected,

wherein the reactant gas is comprised of a first gas and a second gas,

wherein the first gas is delivered to the first half of the zone-distribution section and the second gas is delivered to the second half of the zone-distribution section.

13. A flash MOCVD system according to Claim 12, wherein the substrate assembly is configured to rotate a substrate mounted thereon.

14. A flash MOCVD system according to Claim 9, wherein the one or more pipes of the cooling section are arranged according to the plurality of zones.

15. A flash MOCVD system according to Claim 9, wherein a transparency of the first flow homogenizer is different from a transparency of the second flow homogenizer.

16. A flash MOCVD system according to Claim 9, wherein the second flow homogenizer reflects heat from the substrate assembly away from the gas distribution system.

17. A flash MOCVD system according to Claim 9,

wherein the gas distribution system further comprises:

a plenum positioned upstream from the zone-distribution section; and

a diffuser plate positioned downstream from the plenum and upstream from the zone-distribution section, wherein the diffuser plate is formed with a plurality of holes therein, and

wherein the plenum maintains a higher pressure of the reactant gas relative to a pressure of the reactant gas in the zone-distribution section.

18. A flash MOCVD system according to Claim 9, wherein the second flow homogenizer

is formed of a material that is transparent to infrared radiation,

has a first surface facing the substrate assembly and a second surface opposite the first surface, and

has a reflective coating formed on the second surface to enable the second flow homogenizer to reflect heat regardless of a condition of the first surface.

19. A flash MOCVD system according to Claim 1, wherein the substrate assembly includes a heater for heating a substrate mounted thereon.

20. A flash MOCVD system according to Claim 1, wherein the substrate assembly is configured to cool a substrate mounted thereon.

21. A flash MOCVD system according to Claim 1, wherein the system is configured to form films of lithium niobate having a stoichiometric composition.

22. A flash MOCVD system according to Claim 1, wherein the system is configured to form films of lithium niobate having a non-stoichiometric composition.

23. A flash MOCVD system according to Claim 21 or Claim 22, wherein the system is configured to form doped films of lithium niobate.

24. A flash MOCVD system according to Claim 21 or Claim 22, wherein the gas distribution system controls film uniformity.

25. A flash MOCVD system according to Claim 24, wherein a lithium niobate film deposited on a substrate by the system is uniform in thickness and composition over an entire surface of the substrate.

26. A flash MOCVD system according to Claim 1, wherein the system is configured to produce lithium niobate films with crystallinity ranging from amorphous to polycrystalline to highly oriented to epitaxial, and combinations thereof.

27. A multiple-chamber MOCVD system, comprising:

at least two flash MOCVD systems, wherein each flash MOCVD is a flash MOCVD system according to Claim 1; and

a load-lock system interconnecting the at least two flash MOCVD systems.

28. A multiple-chamber MOCVD system, comprising:

a flash MOCVD system according to Claim 1;

a film deposition system different from the flash MOCVD system; and

a load-lock system interconnecting the flash MOCVD system and the film deposition system.

29. A multiple-chamber MOCVD system according to Claim 27 or Claim 28, wherein the multiple-chamber MOCVD system is configured to form films of ZnO.

30. A multiple-chamber MOCVD system according to Claim 27 or Claim 28,

wherein the multiple-chamber MOCVD system is configured to form a multi-layer structure having a pn junction, and

wherein the multi-layer structure is formed without exposing an interface of the pn junction to atmospheric conditions.

31. A multiple-chamber MOCVD system according to Claim 27 or Claim 28, further comprising an annealing system connected to the load-lock system.

32. A multiple-chamber MOCVD system according to Claim 27 or Claim 28, wherein the system is configured to form *in situ* a film of p-type ZnO, to anneal the film of p-type ZnO, and to form a film of n-type ZnO above the film of p-type ZnO.

33. A multiple-chamber MOCVD system according to Claim 32, wherein the multi-layer structure includes a p-type ZnO layer and an n-type ZnO layer.

34. A multiple-chamber MOCVD system according to Claim 27 or Claim 28,

wherein the multiple-chamber MOCVD system is configured to form a multi-layer structure in which at least one layer is undoped lithium niobate and in which at least one layer is doped lithium niobate.

35. A flash MOCVD system according to Claim 1,

wherein the flash MOCVD system includes a plurality of flash evaporators, and

wherein each of the plurality of flash evaporators produces a different reactant gas.

36. A process for forming lithium niobate by MOCVD, the process comprising the steps of:

preparing a precursor solution containing at least a Li-bearing precursor, a Nb-bearing precursor, and a solvent;

using a flash evaporator to vaporize the solution to produce a reactant gas;

delivering the reactant gas to a heated substrate; and

decomposing the reactant gas on the substrate to deposit a crack-free film of lithium niobate greater that 1.5 μm in thickness.

37. A process according to Claim 36, wherein the solvent is delivered to the flash evaporator at a feed rate between about 0.5 to 10 cc/min.

38. A process according to Claim 36, wherein the solvent is delivered to the flash evaporator at a feed rate between about 1.3 to 2.5 cc/min.

39. A process according to Claim 36, wherein the flash evaporator vaporizes the solution using heat.

40. A process according to Claim 36, wherein the flash evaporator vaporizes the solution using ultrasonic waves.

41. A process according to Claim 36, wherein the film of lithium niobate is stoichiometric.

42. A process according to Claim 36, wherein the film of lithium niobate is non-stoichiometric.

43. A process according to Claim 36, wherein the film of lithium niobate is doped.

44. A process according to Claim 36, wherein the film of lithium niobate is amorphous.

45. A process according to Claim 36, wherein the film of lithium niobate is crystalline.

46. A process according to Claim 36, wherein the step of decomposing the reactant gas results in a film deposition rate greater than 0.2 μm/h.

47. A process according to Claim 36, wherein the step of decomposing the reactant gas results in a film deposition rate of approximately 3 μm/h or greater.

48. A process according to Claim 36, wherein the substrate is heated to a temperature of approximately 625 °C or greater.

49. A process according to Claim 36, wherein the substrate is heated to a temperature of approximately 400 °C or greater.

50. A lithium niobate film formed according to the process of Claim 36.

51. A lithium niobate film according to Claim 50, wherein the lithium niobate film is an optical coating.

52. A process according to Claim 36, wherein the film of lithium niobate has a first index of refraction, and the substrate has a second index of refraction different from the first index of refraction.

53. A process for forming a film by MOCVD, the process comprising the steps of:

preparing a precursor solution containing at least a precursor and a solvent;

using a flash evaporator to vaporize the solution to produce a reactant gas;

delivering the reactant gas to a heated substrate; and

decomposing the reactant gas on the substrate to deposit a crack-free film.

54. A process according to Claim 53, wherein the substrate is lithium niobate.

55. A process according to Claim 53, wherein the film is a metal oxide.

56. A process according to Claim 55, wherein the metal oxide is conductive.

57. A process according to Claim 53, wherein the film is a metal.

58. A process according to Claim 53, wherein the film is an insulator.

59. A flash MOCVD system according to Claim 1,

wherein the gas distribution system comprises:

a zone-distribution section arranged to respectively confine a plurality of quantities of the reactant gas to a plurality of zones; and

a flow homogenizer positioned downstream of the zone-distribution section, wherein the flow homogenizer is formed with a plurality of through-holes therein through which the reactant gas passes, and wherein the flow homogenizer is formed with one or more conduits therein through which a coolant passes, and

wherein the plurality of through holes do not intersect with the one or more conduits.

60. A flash MOCVD system according to Claim 59, wherein the plurality of through holes and the one or more conduits are formed by drilling the flow homogenizer.

61. A process for forming a pn junction, comprising the steps of:

using a first chamber of a multi-chamber deposition system to grow a film of ZnO;

transporting the film of ZnO to a second chamber of the multi-chamber deposition system without exposing the film of ZnO to atmospheric conditions; and

using the second chamber of the multi-chamber deposition system to anneal the film of ZnO.

62. A process according to Claim 61, wherein the film of ZnO is insulating prior to being annealed, and wherein the film of ZnO has a p-type conductivity after being annealed.

63. A process according to Claim 62, further comprising the steps of:

transporting the annealed film of ZnO to a third chamber of the multi-chamber deposition system without exposing the annealed film of ZnO to atmospheric conditions; and

using the third chamber of the multi-chamber deposition system to deposit a second film of ZnO.

64. A process according to Claim 63, wherein the second film of ZnO has an n-type conductivity.

65. A process according to Claim 63 or Claim 64, further comprising the steps of:

transporting the second film of ZnO to the second chamber or to a fourth chamber of the multi-chamber deposition system without exposing the second film of ZnO to atmospheric conditions; and

using the second chamber or the fourth chamber of the multi-chamber deposition system to anneal the second film of ZnO.

66. A process according to Claim 63 or Claim 64, further comprising the steps of:

transporting the second film of ZnO to a fourth chamber of the multi-chamber deposition system without exposing the second film of ZnO to atmospheric conditions; and

using the fourth chamber of the multi-chamber deposition system to form a passivation layer or a metallization layer above the second film of ZnO.

67. A process according to Claim 62, wherein the film of ZnO is doped with N.

68. A process according to Claim 62, wherein hydrogen is removed from the ZnO film when the ZnO film is annealed using the second chamber of the multi-chamber deposition system.

69. A process according to Claim 64, further comprising the step of using a fourth chamber of the multi-chamber deposition system to deposit an insulating film prior to depositing the second film of ZnO using the third chamber of the multi-chamber deposition system.

70. A process according to Claim 64, wherein at least one of the first film of ZnO and the second film of ZnO is deposited with an alloying element to affect a bandgap of the film or films of ZnO.